Abstract

Mechanical vibrations in large structures such as buildings, bridges, dams and critical frequencies in large machinary generally have low frequencies (100Hz - 1000Hz). To monitor large areas of such structures we need huge network of low cost, easily manufacturable, self-powered and stand-alone vibration spectrum sensors. The sensors should also consume very little power during their overall operation cycle and have moderatly high frequency resoultion.

The thesis provides mathematical analysis, design and development of stand-alone, low frequency vibration spectrum analyzer. A mechanically stretched polymer piezoelectric membrane, which has a fixed length and tension, can act as a single frequency detector due to its unique resonant frequency. Stretching multiple ribbons of different lengths and tensions, a vibration spectrum analyzer, which gives the Fourier frequency components present in an arbitary mechanical input vibration, can be designed. The thesis presents a detailed description of experiments to evaluate a low frequency vibration spectrum analyzer system that accepts an incoming input vibration and directly provides the spectrum as output. Polymer piezoelectric materials being easily manufacturable these sensors can be deployed in wide area sensor networks that monitor large structures.

The thesis also shows design of a vibration energy harvesting system based on the concept of harvesting energy at low frequencies. The need for developing such an energy harvesting system arises from the necessity of making the vibration sensor, self-powered. Multiple experimental tests were performed before developing a prototype vibration energy harvesting circuit.